TABLE 19 - WHAT'S NEW? HYBRID VEHICLE TECHNOLOGIES

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Hybrid electric vehicles are vehicles that combine components from both conventional internal combustion engine drivetrains and electric drivetrains. For example, a "series" hybrid vehicle uses an electric motor to drive the wheels; the electricity used to power the motor comes from a battery and an engine/generator combination, with the generator recharging the battery when needed. A "parallel" hybrid has the wheels driven by *both* an electric motor (powered by a battery) and an engine/transmission; the battery might be recharged by a generator attached to the engine. In both series and parallel hybrid vehicles, electricity from regenerative braking also helps to recharge the battery.

What's the point of a hybrid drivetrain, since it's likely to cost more than a conventional drivetrain? Primarily higher efficiency. For one thing, a hybrid can use its electric motor and/or battery to shoulder some of the power needed for hard acceleration, so its engine can be smaller and operate more efficiently than in a conventional drivetrain (the larger engine in a conventional drivetrain operates most often at a small fraction of its maximum power, where it is less efficient). Also, when the vehicle is at rest or slowing down or coasting, any engine-generated energy in excess of auxiliary needs would be lost in a conventional drivetrain; in a hybrid drivetrain, the battery can store this energy for use later on, or the engine can be turned off. And the electric motor can provide some or all of the braking force needed by acting as a generator ("regenerative braking"), with much of the energy that would otherwise have been lost as heat in the mechanical brakes instead becoming energy stored in the battery and available for later use. As an additional benefit, some hybrids can operate for a time as pure electric vehicles, allowing them to enter restricted "pollution-free" zones while retaining their unlimited range (with refueling) outside these zones.

Not surprisingly, these advantages are not all free. Hybrids may be heavier than conventional vehicles, because the weight saved by downsizing the engine and transmission may be more than offset by the added motor/controller, battery and generator. Similarly, costs may be higher with the added complexity, and because batteries and motors are quite expensive. Finally, the added electrical components experience efficiency losses, so some of the energy gained will be offset by losses in the battery, motor, and generator.

One should be wary of generalizations about the fuel economy benefits of hybrids, because there are many alternative design configurations possible, and the efficiency and weight of the electrical drivetrain components will improve with ongoing research and development. Nevertheless, it is clear that hybrids attain their maximum efficiency advantage over conventional vehicles in congested urban traffic or in stop-and-go operation. Test results and computer simulations indicate that some hybrids can double the fuel economy of equivalent conventional vehicles in this type of traffic or operation. This type of performance, coupled with emission advantages described below, imply that hybrid drivetrain technology would be particularly useful for vehicles such as transit buses and garbage trucks operating in most cities, and taxicabs operating in congested urban centers.

What about emissions. Well, hybrids have certain advantages, especially because their engines can be more easily kept out of operating conditions that tend to push emissions up. However, depending on the vehicle's design and operating strategy, a hybrid's engine may turn on and off considerably more often than the engine in its conventional counterpart, leading to some added emissions. Also, vehicle emissions are probably a stronger function of engine and emissions control system design and fuel composition than whether the drivetrain is conventional or hybrid. This is especially true for light-duty vehicles; heavy trucks, especially vehicles such as urban buses and garbage trucks, experience such stressful duty cycles that the ability of hybrid drivetrains to moderate the strong engine transients may be extremely valuable in emissions control.

Some hybrid vehicles being marketed today or being tested in prototype form are:

The **Toyota Prius** is a subcompact hybrid auto introduced into the Japanese market last year. It attains 66 mpg on the Japanese test cycle, and about 50 mpg on the U.S. CAFE cycle, which is more challenging. EPA calculates that Prius's hybrid system yields about a 35 percent improvement in fuel economy, with additional improvements from better tires, aerodynamics, etc. The Prius uses nickel-metal hydride batteries designed for high power.

The **Honda VV** hybrid vehicle is scheduled for a U.S. launch this fall. The car meets California's Ultra Low Emission Vehicle standards, has a 1.0-L, three-cylinder lean-burn VTEC (variable valve) engine and is said to attain a city/highway fuel economy of 70 mpg.

The **Navistar Hybrid Electric Vehicle** is a prototype heavy-duty series hybrid vehicle using a diesel engine as its power source. It uses lead-acid maintenance-free batteries. Lockheed-Martin is its co-developer. Its expected fuel economy improvement over a conventional vehicle is 20-30% in urban stop-and-go traffic, and 10-15% in suburban driving. Target emissions level is ULEV